PATENT

In the United States Patent and Trademark Office

Applicant: L. Rosenberg et al.
Applicant's Ref: IMM1P007D.US
Application No: Unassigned
Filed: January 8, 2001
Title: Interface Device For Sensing Position and Orientation and Outputting Force to a User (as amended)

Examiner: Unassigned
Group Art Unit: Unassigned

PRELIMINARY AMENDMENT A

Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Please amend the above-identified patent application as follows before the examination of the application:

In the Title

Please change the title to: -- Interface Device For Sensing Position and Orientation and Outputting Force to a User --.

In the Drawings:

The drawings have been amended as indicated in red on the enclosed photocopies.

In the Abstract:

Please delete the Abstract of the Disclosure and replace with the Abstract provided on the separate sheet included herewith.

CLEAN VERSION OF AMENDMENTS

In the Specification:

Insert on page 1, line 2, the following paragraph:

This application is a continuation of U.S. Application No. 09/511,413, filed February 23, 2000, which is a continuation of U.S. Application No. 09/248,175, now Patent No. 6,046,727, filed February 9, 1999, which is a continuation of U.S. Application No. 08/784,198, now Patent No. 5,880,714, filed January 15, 1997, which is a continuation of U.S. Application No. 08/583,032, now Patent No. 5,701,140, filed on February 16, 1996, which claims priority under 35 U.S.C. §120 to U.S. Application No. 08/092,974, filed July 16, 1993, now abandoned; where application no. 08/583,032 is the national stage of International Application No. PCT/US94/07851, filed 12 July 1994.

Replace the paragraph starting on page 1, line 3, with:

The present invention relates to a computer-human interface device, and more particularly it relates to a stylus coupled to a supportable mechanical linkage for providing and receiving commands to and from a computer.

Insert on page 3, line 3, the following paragraph:

An embodiment of the present invention includes computer software and hardware which will provide force feedback information from the computer to the stylus. The computer sends feedback signals to the mechanical linkage which has force generators for generating force in

response to images depicted on the computer screen. Incoming commands from the host computer are monitored by the microprocessor and instruct the microprocessor to report forces felt by a joint or set forces on a joint of the mechanical linkage.

Replace the paragraph starting on page 4, line 5, with:

Figure 3 is a flow chart describing the main software command loop for two different electronic hardware configurations shown in FIG. 2;

Insert on page53, line 12 after "apparatus", the following paragraph:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus and cause forces on the stylus. This implementation is described in greater detail subsequently.

Replace the paragraph starting on page 5, line 21, with:

Because the stylus is supported by a support apparatus which is in turn supported by a fixed surface or other stabilizing configuration, the user can manipulate the stylus with a minimum of effort. Also, if the user chooses to discontinue using the stylus, it is capable of maintaining its position in space, unattended. While FIG. 1 shows that preferred embodiment of the present invention, FIGS. 5-8 show alternative embodiments, such which are also contemplated under the present invention. It is preferable that the stylus have enough degrees of freedom to enable it to move through the mechanical linkage to give the user the amount of flexibility needed to move the cursor as desired. In FIG. 1, six degrees of freedom are shown and are labeled as Axes A1, A2, A3, A4, A5, and A6. This, of course, provides maximum flexibility. Fewer degrees of freedom, such as a plurality of degrees of freedom, may also be sufficient depending on the application.

Replace the paragraph starting on page 7, line 1, with:

As mentioned above, attached to each joint 12, 15 and 18 are sensors 13A, 13B, 16A, 16B, 19A, and 19B, respectively. These sensors sense the angle differential before and after motion of the two segments connected by that joint. The sensors can be, for example, optical

incremental encoders, optical absolute encoders and potentiometers. Because the three-dimensional position and/or orientation tracking is achieved mechanically, this preferred embodiment avoids problems that magnetic and ultrasonic sensors, such as those shown in the prior art, encounter with metal and shadowing. However, as shown in FIG. 1, if desired, sensing means can be used to track the position and/or orientation of the stylus by mounting a single or several orientation sensors in the stylus 11 itself, such referred to as a stylus mounted sensor 11'. An ultrasound, magnetic, optical or position and orientation sensor can be used as the stylus mounted sensor 11'.

Replace the paragraph starting on page 8, line 1, with:

Referring to FIG. 2A, the sensors 13A, 13B, 16A, 16B, 19A and 19B, along with any peripherals 24, 25, or 26, can send their digital signals directly to a versatile floating-point processor or microprocessor 32A which is controlled by software stored in a digital ROM (Read-Only Memory) 35 via transmission line 32' or another form of transmission, i.e., radio signals. As shown in FIG. 2B, an alternative embodiment can be used to lessen the demands on the floating-point processor or microprocessor 32B. The digital inputs of the sensors 13A, 13B, 16A, 16B, 19A and 19B can be sent indirectly to the floating-point processor or microprocessor 32B by way of dedicated chips 13C, 13D, 16C, 16D, 19C and 19D, which pre-process the angle sensors' signals before sending them via bus 31 to the floating-point processor or microprocessor 32B which would combine these signals with those from the peripherals 24, 25 or 26. An 8-bit data bus plus chip-enable lines allow any of the angle determining chips to communicate with the microprocessor. Moreover, reporting the status of peripherals 24, 25 or 26 includes reading the appropriate digital switch and placing its status in the output sequence array. Some examples of specific electronic hardware usable for sensor pre-processing include quadrature counters, which are common dedicated chips that continually read the output of an optical incremental encoder and determine an angle from it, Gray decoders, filters, and ROM look-up tables.

Replace the paragraph starting on page 9, line 17, with:

Referring to FIG. 3, the main command loop responds to the host computer 34 and runs repeatedly in an endless cycle. With each cycle, incoming commands 40 from the host computer are monitored 36 and decoded 37, and the corresponding command subroutines for reporting

angles, thus stylus position and/or orientation (see FIGS. 4A and 4B), are then executed 38. Two possible subroutines are shown in FIGS. 4A (single-chip method) and 4B (multi-chip method). When a subroutine terminates, the main command loop resumes 39. Available command will include but are not limited to: reporting the value of any single angle, reporting the angles of all six angles at one time, reporting the values of all six angles repeatedly until a command is given to cease aforementioned repeated reporting, reporting the status of peripheral buttons, and setting communications parameters. If the angle sensors require preprocessing, these commands will also include resetting the angle value of any single angle or otherwise modifying preprocessing parameters in other applicable ways. Resetting pre-processed angle values or preprocessing parameters does not require output data from the device. The microprocessor 32A or 32B simply sends appropriate control signals to the preprocessing hardware 13C, 13D, 16C, 16D, 19C, and 19D. If the microprocessor or floating-point processor is fast enough to compute stylus coordinates and orientation, these commands will also include reporting the stylus coordinates once, reporting the stylus coordinates repeatedly until a command is given to cease, ceasing aforementioned repeated reporting, reporting the stylus coordinates and orientation once, reporting the stylus coordinates and orientation repeatedly until a command is given to cease, and ceasing aforementioned repeated reporting. If force reflection is supported, these commands will also include reporting the forces felt by any single joint, setting the resistance of any single joint, and locking or unlocking a joint.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other command subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other command subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 25, with:

After determining the given joint angle, the microprocessor 32A or 32B creates an output sequence 44A or 44B by assembling an array in a designated area of processor memory 35 which will be output by the microprocessor's communications system at a given regular communications rate. The sequence will contain enough information for the host computer 34 to deduce which command is being responded to, as well as the actual angle value that was requested. Returning to FIG. 3, a query 36 in the main command loop asks whether the previous command requested repeated reports. If so, the main command loop is initiated accordingly. The communications output process (not shown) may be as simple as storing the output data in a designated output buffer, or it may involve a standard set of communications interrupts that are an additional part of the software. Setting communications parameters does not require output data from the device. The microprocessor 32A or 32B simply resets some of its own internal registers or sends control signals to its communications sub-unit.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 coordinates, three of the five or six angle values are pre-read and knowledge of link lengths and device kinematics are incorporated to compute stylus 11 coordinates. These coordinates are then assembled in the output sequence array.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 orientation, at least five angle values are read and knowledge of link lengths and device kinematics are incorporated to compute stylus 11 orientation. The orientation consists of three angles (not necessarily identical to any joint angles) which are included in the output sequence array.

Replace the paragraph starting on page 11, line 18, with:

Forces felt by a joint are reported, and setting a joint's resistance, and locking or unlocking a joint are accomplished by using interaction of the microprocessor 32A or 32B with force-reflecting hardware. Reporting forces felt by a joint uses a force sensor mounted on the joint and then places the resulting value in the output sequence array. To set a joint's resistance and lock or unlock a joint, control signals are used to control force-reflection hardware, and do not require any output data from the device.

Replace the paragraph starting on page 11, line 25, with:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus, such as host commands 40 (shown in Fig. 1). This type of implementation is known in robotics and thus is easily incorporated into a system including the present invention. When a surface is generated on the computer screen, the computer will send feedback signals to the mechanical linkage which has force generators identified by numerals 13A, 13B, 16A, 16B, 19A, and 19B (which also identifies the sensors, see above) for generating force F (see Fig. 1) in response to the cursor position on the surface depicted on the computer screen. Force is applied for example, by added tension in the joints which is in proportion to the force being applied by the user and in conjunction with the image on the screen.

Replace the paragraph starting on page 12, line 16, with:

Briefly, FIG. 5 shows an embodiment having 6 rotary joints including a rounded joint 46 at the base such that three degrees of motion are available at that joint. FIG. 6 shows an embodiment having 5 rotary joints and one linear joint, including a three-dimensionally rotatable

rounded joint 47 at the base through which one mechanical linkage can slide linearly and where the base is attached to a fixed surface 48 such that the surface does not prohibitively impede the movement of the device. FIG. 7 shows an embodiment having 3 rotary joints and 3 linear joints, where the basal connection can slide about the base in a two-dimensional plane in the cross configuration 49 on base 51. FIG. 8 shows an embodiment having 5 rotary joints and 3 linear joints, including three-dimensionally rotatable rounded joint 52 at a perpendicular projection from the base 53 through which one mechanical linkage 54 can slide linearly through the joint 52.

Replace the paragraph starting on page 12, line 25, with:

While any of the above discussed configurations or others can be used in accordance with the present invention, FIGS. 9-11 show different mechanisms for providing resistance to the manual manipulation of the stylus by the user. FIG. 9, for example, shows return or tension springs 56 on each joint of the embodiment shown in FIG. 1. In an alternative embodiment, FIG. 10, shows counter-weights 57 on each joint. Moreover, FIG. 11, shows a combination of a return or tension spring 56, a counter-weight 57 and a compression spring 58. The arrangement of the resistance mechanism used should depend upon the configuration stylus mechanical linkage combination, such arrangement preferably chosen to maximize the ease with which the user can manipulate the stylus 11 in free space in accordance with the present invention.

<u>In the Claims:</u>

All pending claims are listed below. Claims which have been changed by this amendment are marked as "amended." No Marked-up version of the claims is provided since all pending claims are new.

Please cancel claims 1-26 without prejudice.

Please add the following claims:

27. (new) A human interface device for enabling manual interactions with application software running on a host computer, said software providing images displayed on a display apparatus, said device comprising:

(a) a user manipulatable physical object physically contacted and moveable by a user, said user manipulating said user manipulatable physical object in a plurality of rotational degrees of freedom with respect to a surface, wherein three of said degrees of freedom closest to said user manipulatable object allow an orientation of said object to be adjusted in three dimensional space while three degrees of freedom closest to said surface allow a location of said object to be adjusted in three dimensional space;

(b) a sensor apparatus coupled to at least one of said user manipulatable physical object and said support mechanism and that produces a locative signal which is responsive to and corresponding with said location and said orientation of said user manipulatable physical object with respect to said surface at points in time during normal operation;

(c) a communication bus coupled to said host computer;

(d) a device microprocessor separate from said host computer and coupled to said host computer by said communication bus, said device microprocessor being coupled to said sensor apparatus, said device microprocessor running a program contained at least in part in a non-volatile memory coupled to said device microprocessor and separate from said host computer, said device microprocessor providing information for use by said host computer running an application program simultaneously with said microprocessor running said program, said information including a representation of said locative signal,

wherein said application program of said host computer can provide images on a computer display, said images updated on said computer display in response to said locative signal, and

wherein said host computer can provide host commands, said host commands being communicated to said device microprocessor by said communication bus, wherein said device microprocessor:

(i) monitors said communication bus for said host commands; and

(ii) decodes said host commands, wherein

at least one of said host commands causes information to be reported from said device microprocessor to said host computer, and

at least one of said host commands causes said device microprocessor to output control signals to cause a force to be output to said user, said at least one host command and said force being correlated with at least one of said images developed by said host computer on said computer display; and

(e) a force generator controlled by said device microprocessor for providing a force to to said user in response to at least one of said control signals.

28. (new) A human interface device as recited in claim 27 further comprising a support mechanism which supports said user manipulatable physical object while allowing said plurality of degrees of freedom in the motion of said user manipulatable physical object.

29. (new) A human interface device as recited in claim 28 wherein said support mechanism includes a linkage coupled between said user manipulatable physical object and said surface.

30. (new) A human interface device as recited in claim 27 wherein said user manipulatable physical object has a pencil-like stylus configuration that can be manually manipulated by a user of said device.

31. (new) A human interface device as recited in claim 27 further comprising a switch coupled to said user manipulatable object, said switch capable of being in multiple states in response to user interaction, wherein a state of said switch being transmitted to said host computer and wherein an action is taken by said host computer in response to said state of said switch.

32. (new) A human interface device as recited in claim 27 further comprising a plurality of command routines stored in said local memory, at least one of said command routines allowing said microprocessor to control said force generator in accordance with at least one of said decoded host commands, and at least one of said command routines reporting a representation of said locative signal to said host computer in accordance with at least one of said decoded host commands.

33. (new) A human interface device as recited in claim 27 wherein said device microprocessor computes the position or orientation of said user manipulatable object from said locative signal produced by said sensor apparatus, said microprocessor reporting said position or orientation to said host computer.

34. (new) A human interface device as recited in claim 27 wherein said device microprocessor executes a routine stored in a non-volatile memory accessible by said device microprocessor and based on said host command, wherein said routine processes said locative signal into angle data, and wherein said angle data is sent to said host computer.

35. (new) A human interface device as recited in claim 27 wherein said force generator transmits a force via said support mechanism in response to said force signals, and

wherein said force signals are correlated to information displayed on said computer display apparatus, said information including a cursor interacting with a graphical surface.

36. (new) A human interface device as recited in claim 27 wherein at least one of said host commands calls a subroutine stored on said microprocessor to change a resistance at a joint of said support mechanism.

37. (new) A human interface device as recited in claim 27 wherein forces commanded by said host computer to said device microprocessor and felt by said user correspond to images displayed on said computer display, wherein said images include a cursor interacting with another object displayed on said display screen, wherein said cursor interacts with a surface image displayed on said display screen.

38. (new) An interface device for use in conjunction with a host computer, wherein images are displayed on a computer display apparatus coupled to said host computer, said interface device comprising:

a user manipulatable object engaged by a user's hand to allow dexterous manipulations by fingers of said user;

a mechanical linkage coupled to a fixed surface by a base rotary joint and coupled to said user manipulatable object by an object rotary joint, said linkage for supporting said object allowing at least five degrees of freedom in motion of said object with respect to said fixed surface, wherein said mechanical linkage provides said degrees of freedom through a structure of substantially rigid members joined by a plurality of rotary joints, said mechanical linkage providing said user the ability to manipulate both the location and orientation of said object in three dimensional space, and wherein a configuration of said degrees of freedom allow said user to rotate said object about a fixed point in space when three degrees of freedom closest to said fixed surface are held fixed and when remaining ones of said degrees of freedom are moved;

one or more sensors for producing an interactive object locative signal which is responsive to and corresponding with the position and orientation of the user manipulatable object, said object locative signal providing information about the location and angle of said user manipulatable object for use by said host computer to manipulate images displayed by said computer display apparatus in accordance with said location and angle of said user manipulatable object, said images including a cursor whose position and orientation on said computer display apparatus is influenced by said user manipulatable object locative signal; and

a force generator for generating a force on said user object in at least one of said five degrees of freedom in response to force signals provided to said interactive device, said force signals correlated to information displayed on said computer display apparatus including interaction of said cursor with other images on said computer display apparatus.

39. (new) An interface device as recited in claim 38 wherein said linkage allows six degrees of freedom in motion of said object, wherein three of said degrees of freedom closest to said user manipulatable object allow an orientation of said object to be adjusted in three dimensional space while three degrees of freedom closest to said fixed surface allow a location of said object to be adjusted in three dimensional space.

40. (new) An interface device as recited in claim 38 wherein a configuration of said joints allows said user manipulatable object to spin freely about an axis extending through the length of said object while all others of said joints remain fixed in position.

41. (new) An interface device as recited in claim 38 wherein said user manipulatable object is a stylus having a pen-like configuration to allow writing-like manipulations between said fingers.

42. (new) An interface device for use in conjunction with a host computer and a fixed surface, said device comprising:

a user manipulatable object moveable by a user;

a mechanical linkage coupled to said fixed surface by a base rotary joint and coupled to said user manipulatable object by an object rotary joint, said mechanical linkage allowing at least five degrees of freedom in the motion of said object with respect to said fixed surface, wherein said mechanical linkage provides said degrees of freedom through a structure of substantially rigid members joined by a plurality of rotary joints, said mechanical linkage providing said user the ability to manipulate both a location and an orientation of said object in three dimensional space;

at least one sensor for producing a locative signal which is responsive to a position and orientation of said user manipulatable object, said locative signal providing information about the position and orientation of said user manipulatable object for use by said host computer;

at least one force generator for applying a force to a corresponding rotary joint of said mechanical linkage in response to force signals provided to said position sensing device from said host computer, wherein images are displayed on a computer display apparatus coupled to

said host computer, and wherein said force signals are correlated to information displayed on said computer display apparatus; and

a device microprocessor that receives said force signals from said host computer and provides said force signals to said force generator.

43. (new) An interface device as recited in claim 42 wherein said device microprocessor receives said locative signal from said at least one sensor and outputs a signal based on said locative signal to said host computer.

44. (new) An interface device as recited in claim 42 wherein one of said images displayed by said computer display apparatus is manipulated in accordance with said location of said user manipulatable object, said manipulated image including a cursor having a position on said computer display apparatus influenced by said locative signal.

45. (new) An interface device as recited in claim 42 wherein a configuration of said degrees of freedom allow said user to rotate said object about a fixed point in space when three degrees of freedom closest to said fixed surface are held fixed and when remaining degrees of freedom are moved.

46. (new) An interface device as recited in claim 42 wherein said linkage allows six degrees of freedom in motion of said object, wherein three of said degrees of freedom closest to said user manipulatable object allow an orientation of said object to be adjusted in three dimensional space while three degrees of freedom closest to said fixed surface allow a location of said object to be adjusted in three dimensional space.

47. (new) An interface device for use in conjunction with a host computer, images displayed on a computer display screen, and a fixed surface, comprising:

a stylus having a pencil-like configuration to allow writing-like manipulations between fingers of a user;

a mechanical linkage coupled to a fixed surface and coupled to said stylus for supporting said stylus while allowing at least five degrees of freedom in the motion of said stylus, said mechanical linkage providing a user the ability to manipulate both the orientation and location of said stylus in three-dimensional space;

a sensor for producing an interactive stylus locative signal which provides information about the position and orientation of said stylus for use by said host computer and said computer display screen to manipulate images displayed by said computer display screen in accordance with said orientation, location, or movement of said stylus, said images including a cursor whose position on said computer display screen is controlled by said stylus locative signal; and

a force generator for generating a force on said stylus in at least one of said five degrees of freedom in response to force signals provided to said interactive device, said force signals correlated to information displayed on said computer display screen.

48. (new) A device as recited in claim 47 wherein said mechanical linkage includes at least five joints, wherein a configuration of said joints allows said stylus to spin freely about an axis extending through the length of said stylus while all of said other joints remain fixed in position, and a sensor for sensing said spin and providing a signal describing said spin to said host computer.

49. (new) A device as recited in claim 47 wherein three joints of said mechanical linkage closest to said stylus control said orientation of said stylus, said orientation being variable by a user while a position of a point on said stylus remains fixed.

50. (new) A device as recited in claim 47 further comprising a local memory and a device microprocessor decoding host commands received from said host computer, wherein a plurality of command routines are stored in said local memory, at least one of said command routines allowing said device microprocessor to control said force generator in accordance with at least one of said decoded host commands, and at least one of said command routines reporting a representation of said locative signal to said host computer in accordance with at least one of said decoded host commands.

51. (new) A method for interactively interfacing a user and a computer, the method comprising:

providing a stylus having a pencil-like configuration that allows writing-like manipulations between fingers of said user, said stylus coupled to a mechanical linkage coupled to a fixed surface for supporting said stylus while allowing at least five degrees of freedom in the motion of said stylus, said mechanical linkage for providing a user the ability to manipulate the orientation and location of said stylus in three-dimensional space;

producing an interactive stylus locative signal which is responsive to and corresponding with the position and movement of the stylus at any point in time during its normal operation, said stylus locative signal providing information about the orientation and location of said stylus;

causing a cursor to be displayed by said computer, said computer using said stylus locative signal to position and move said cursor in accordance with the location, orientation, or movement of said stylus; and

providing a force generator operative to generate force on said stylus in at least one of said degrees of freedom in response to force signals provided by said computer to said mechanical linkage, said force signals correlated to information displayed by said computer.

52. (new) A method as recited in claim 51 wherein said mechanical linkage provides said stylus with six degrees of freedom.

53. (new) A method as recited in claim 51 wherein said feedback means generates a force on said stylus by generating a force on a joint included in said mechanical linkage in response to said force signals.

54. (new) A method as recited in claim 51 wherein when said cursor displayed by said computer moves into a different image displayed by said computer, a force signal is output and a force is generated by said force generator in at least one of said plurality of degrees of freedom.

ABSTRACT OF THE DISCLOSURE

An interface device for use with a computer that provides locative data to a computer for tracking a user manipulatable physical object and provides feedback to the user through output forces. The physical object is movable in multiple degrees of freedom and is tracked by sensors for sensing the location and orientation of the object. A device processor can be responsive to the output of the sensors and can provide the host computer with information derived from the sensors. The host computer can provides images on a display, where the computer responds to the provided sensor information and force feedback is correlated with the displayed images via force feedback commands from the host computer.

REMARKS

Claims 27-54 are pending in this application. Claims 1-26 have been cancelled and claims 27-54 have been added by this amendment. Applicant reserves the right to reintroduce claims of comparable scope to the original claims in a continuation or other related application.

Applicant has amended the specification, abstract, and drawings to be in accord with the amended claims. No new matter has been added by these amendments.

Applicant believes that all pending claims are allowable and respectfully requests a Notice of Allowance from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the telephone number set out below.

Respectfully submitted,

James R. Riegel
Reg. 36,651

San Jose, California
408-467-1900

MARKED-UP VERSION OF AMENDMENTS

In the Specification:

Replace the paragraph starting on page 1, line 3, with:

The present invention relates to a computer-human interface device, and more particularly it relates to a stylus coupled to a supportable mechanical linkage for providing and receiving commands to and from a computer.

Insert on page 3, line 3, the following paragraph:

An embodiment of the present invention includes computer software and hardware which will provide force feedback information from the computer to the stylus. The computer sends feedback signals to the mechanical linkage which has force generators for generating force in response to images depicted on the computer screen. Incoming commands from the host computer are monitored by the microprocessor and instruct the microprocessor to report forces felt by a joint or set forces on a joint of the mechanical linkage.

Replace the paragraph starting on page 4, line 5, with:

Figure 3 is a flow chart describing the main software [loops] command loop for two different electronic hardware configurations shown in FIG. 2;

Insert on page53, line 12 after "apparatus", the following paragraph:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus and cause forces on the stylus. This implementation is described in greater detail subsequently.

Replace the paragraph starting on page 5, line 21, with:

Because the stylus is supported by a support apparatus which is in turn supported by a fixed surface or other stabilizing configuration, the user can manipulate the stylus with a minimum of effort. Also, if the user chooses to discontinue using the stylus, it is capable of

maintaining its position in space, unattended. While FIG. 1 shows that preferred embodiment of the present invention, FIGS. 5-8 show alternative embodiments, such which are also contemplated under the present invention. It is preferable that the stylus have enough degrees of freedom to enable it to move through the mechanical linkage to give the user the amount of flexibility needed to move the cursor as desired. In FIG. 1, six degrees of freedom are shown and are labeled as [Axis' 16] Axes A1, A2, A3, A4, A5, and A6. This, of course, provides maximum flexibility. Fewer degrees of freedom, such as a plurality of degrees of freedom, may also be sufficient depending on the application.

Replace the paragraph starting on page 7, line 1, with:

As mentioned above, attached to each joint 12, 15 and 18 are sensors 13A, 13B, 16A, 16B, 19A, and 19B, respectively. These sensors sense the angle differential before and after motion of the two segments connected by that joint. The sensors can be, for example, optical incremental encoders, optical absolute encoders and potentiometers. Because the three-dimensional position and/or orientation tracking is achieved mechanically, this preferred embodiment avoids problems that magnetic and ultrasonic sensors, such as those shown in the prior art, encounter with metal and shadowing. However, as shown in FIG. 1, if desired, sensing means can be used to track the position and/or orientation of the stylus by mounting a single or several orientation sensors in the stylus 11 itself, such referred to as a stylus mounted sensor [11] 11'. An ultrasound, magnetic, optical or position and orientation sensor can be used as the stylus mounted sensor [11] 11'.

Replace the paragraph starting on page 8, line 1, with:

Referring to FIG. 2A, the sensors 13A, 13B, 16A, 16B, 19A and 19B, along with any peripherals 24, 25, or 26, can send their digital signals directly to a versatile floating-point processor or microprocessor 32A which is controlled by software stored in a digital ROM (Read-Only Memory) 35 via transmission line 32' or another form of transmission, i.e., radio signals. As shown in FIG. 2B, an alternative embodiment can be used to lessen the demands on the floating-point processor or microprocessor 32B. The digital inputs of the sensors 13A, 13B, 16A, 16B, 19A and 19B can be sent indirectly to the floating-point processor or microprocessor 32B by way of dedicated chips 13C, 13D, 16C, 16D, 19C and 19D, which pre-process the angle sensors' signals before sending them via bus 31 to the floating-point processor or microprocessor

32B which would combine these signals with those from the peripherals 24, 25 or 26. An 8-bit data bus plus chip-enable lines allow any of the angle determining chips to communicate with the microprocessor. Moreover, reporting the status of peripherals 24, 25 or 26 includes reading the appropriate digital switch and placing its status in the output sequence array. Some examples of specific electronic hardware usable for sensor pre-processing include quadrature counters, which are common dedicated chips that continually read the output of an optical incremental encoder and determine an angle from it, Gray decoders, filters, and ROM look-up tables.

Replace the paragraph starting on page 9, line 17, with:

Referring to FIG. 3, the main command loop responds to the host computer 34 and runs repeatedly in an endless cycle. With each cycle, incoming commands <u>40</u> from the host computer are monitored 36 and decoded 37, and the corresponding command subroutines for reporting angles, thus stylus position and/or orientation (see FIGS. 4A and 4B), are then executed 38. Two possible subroutines are shown in FIGS. 4A <u>(single-chip method)</u> and 4B <u>(multi-chip method)</u>. When a subroutine terminates, the main command loop resumes 39. Available command will include but are not limited to: reporting the value of any single angle, reporting the angles of all six angles at one time, reporting the values of all six angles repeatedly until a command is given to cease aforementioned repeated reporting, reporting the status of peripheral buttons, and setting communications parameters. If the angle sensors require preprocessing, these commands will also include resetting the angle value of any single angle or otherwise modifying preprocessing parameters in other applicable ways. Resetting pre-processed angle values or preprocessing parameters does not require output data from the device. The microprocessor 32A or 32B simply sends appropriate control signals to the preprocessing hardware 13C, 13D, 16C, 16D, 19C, and 19D. If the microprocessor or floating-point processor is fast enough to [computer] <u>compute</u> stylus coordinates and orientation, these commands will also include reporting the stylus coordinates once, reporting the stylus coordinates repeatedly until a command is given to cease, ceasing aforementioned repeated reporting, reporting the stylus coordinates and orientation once, reporting the stylus coordinates and orientation repeatedly until a command is given to cease, <u>and</u> ceasing aforementioned repeated reporting. If force reflection is supported, these commands will also include reporting the forces felt by any single joint, setting the resistance of any single joint, and locking or unlocking a joint.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other command subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 13, with:

Any report by the subroutines of FIGS. 4A and 4B of a single angle value requires determining 41 the given joint angle. For the single-chip configuration shown in FIG. 2A, this subroutine directly reads the appropriate angle sensor 42 from among sensors 13A, 13B, 16A, 16B, 19A, and 19B. For the multi-chip configuration shown in FIG. 2B, this subroutine reads the outputs 43 of pre-processing hardware 13C, 13D, 16C, 16D, 19C, and 19D which have already determined the joint angles from the outputs of the sensors 13A, 13B, 16A, 16B, 19A, and 19B. Any report of multiple angles is accomplished by repeatedly executing the subroutine for reporting a single angle. The subroutine is executed once per angle, and the values of all angles are then included in the output sequence array. If the optional parts of the subroutines 45 are included, then these subroutines become the coordinate reporting subroutines. Many other [commend] <u>command</u> subroutines exist and are simpler yet in their high-level structure.

Replace the paragraph starting on page 10, line 25, with:

After determining the given joint angle, the microprocessor 32A or 32B creates an output sequence 44A or 44B by assembling an array in a designated area of processor memory <u>35</u> which will be output by the microprocessor's communications system at a given regular

communications rate. The sequence will contain enough information for the host computer 34 to deduce which command is being responded to, as well as the actual angle value that was requested. Returning to FIG. 3, a query 36 in the main command loop asks whether the previous command requested repeated reports. If so, the main command loop is initiated accordingly. The communications output process (not shown) may be as simple as storing the output data in a designated output buffer, or it may involve a standard set of communications interrupts that are an additional part of the software. Setting communications parameters does not require output data from the device. The microprocessor 32A or 32B simply resets some of its own internal registers or sends control signals to its communications sub-unit.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 coordinates, three of the five or six angle values are pre-read and knowledge of link lengths and device kinematics are incorporated to compute stylus 11 coordinates. These coordinates are then assembled in the output sequence array.

Replace the paragraph starting on page 11, line 14, with:

To report the stylus' 11 orientation, at least five angle values are read and knowledge of link lengths and device kinematics are incorporated to [computer] compute stylus 11 orientation. The orientation consists of three angles (not necessarily identical to any joint angles) which are included in the output sequence array.

Replace the paragraph starting on page 11, line 18, with:

Forces felt by a joint are reported, and setting a joint's resistance, and locking or unlocking a joint are [reported] accomplished by using interaction of the microprocessor 32A or 32B with [forced] force-reflecting hardware [(not shown)]. Reporting forces felt by a joint uses a force sensor mounted on the joint and then places the resulting value in the output sequence array. To set a joint's resistance and [locking] lock or [unlocking] unlock a joint, control signals [reading from a force sensor to] are used to control force-reflection hardware [but] , and do not require any output data [of] from the device.

Replace the paragraph starting on page 11, line 25, with:

Also contemplated in the present invention is computer software and hardware which will provide feedback information from the computer to the stylus [(not shown)] , such as host commands 40 (shown in Fig. 1). This type of implementation is known in robotics and thus is easily incorporated into a system including the present invention. When a surface is generated on the computer screen, the computer will send feedback signals to the mechanical linkage which has force generators identified by numerals 13A, 13B, 16A, 16B, 19A, and 19B (which also identifies the sensors, see above) for generating force F (see Fig. 1) in response to the cursor position on the surface depicted on the computer screen. Force is applied for example, by added tension in the joints which is in proportion to the force being applied by the user and in conjunction with the image on the screen.

Replace the paragraph starting on page 12, line 16, with:

Briefly, FIG. 5 shows an embodiment having 6 rotary joints including a rounded joint 46 at the base such that three degrees of motion are available at that joint. FIG. 6 shows an embodiment having 5 rotary joints and one linear joint, including a three-dimensionally rotatable rounded joint 47 at the base through which one mechanical linkage can slide linearly and where the base is attached to a fixed surface 48 such that the surface does not prohibitively impede the movement of the device. FIG. 7 shows an embodiment having 3 rotary joints and 3 linear joints, where the basal connection can slide about the base in a two-dimensional plane in the cross configuration 49 on base 51. FIG. 8 shows an embodiment having 5 rotary joints and 3 linear joints, including three-dimensionally rotatable rounded joint 52 at a perpendicular projection from the base 53 through which one mechanical linkage 54 can slide linearly through the joint 52.

Replace the paragraph starting on page 12, line 25, with:

While any of the above discussed configurations or others can be used in accordance with the present invention, FIGS. 9-11 show different mechanisms for providing resistance to the manual manipulation of the stylus by the user. FIG. 9, for example, shows return or tension springs 56 on each joint of the embodiment shown in FIG. 1. In an alternative embodiment, FIG. 10, shows counter-weights 57 on each joint. Moreover, FIG. 11, shows a combination of a return

or tension spring 56, a [counter-wight] counter-weight 57 and a compression spring 58. The arrangement of the resistance mechanism used should depend upon the configuration stylus mechanical linkage combination, such arrangement preferably chosen to maximize the ease with which the user can manipulate the stylus 11 in free space in accordance with the present invention.

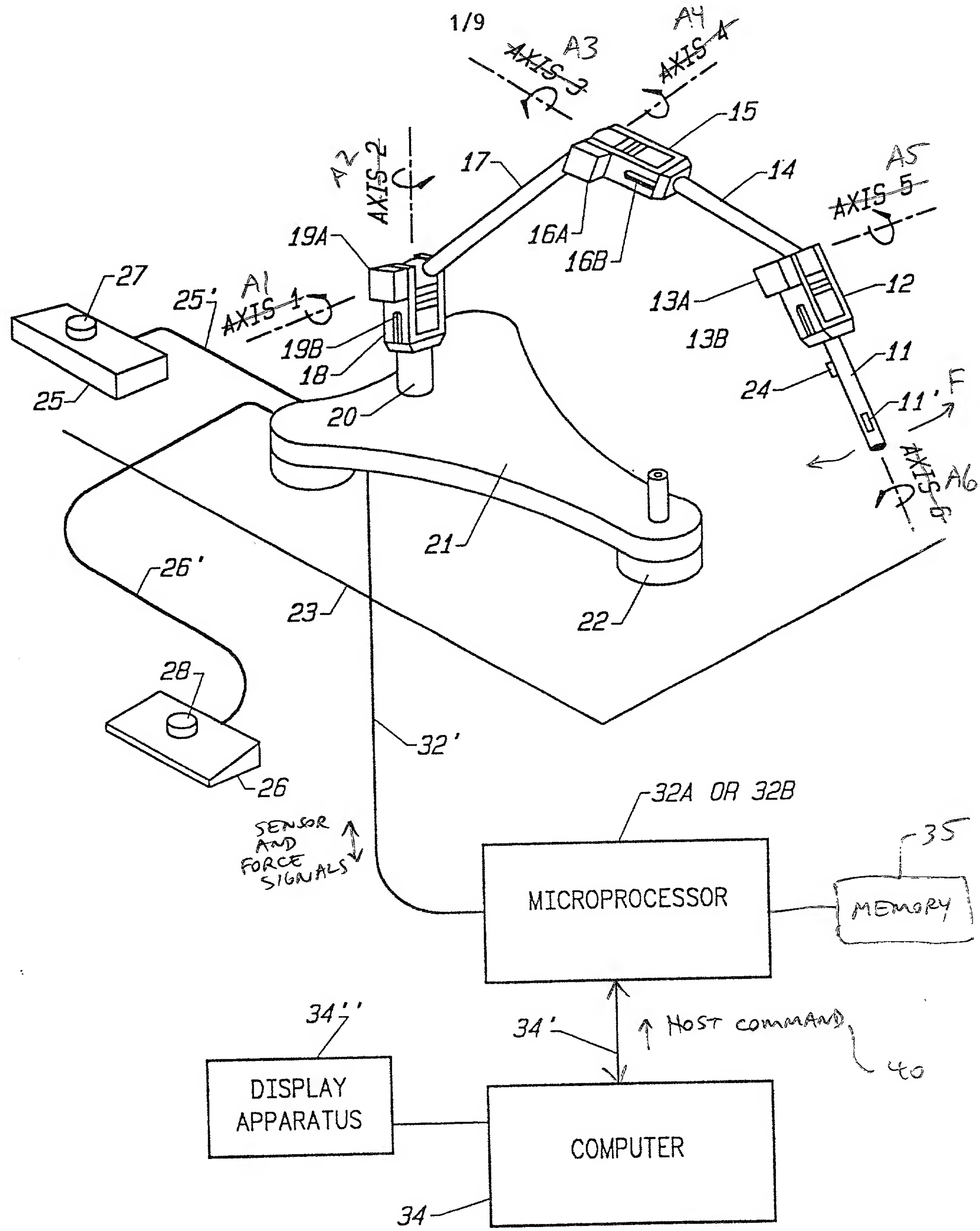
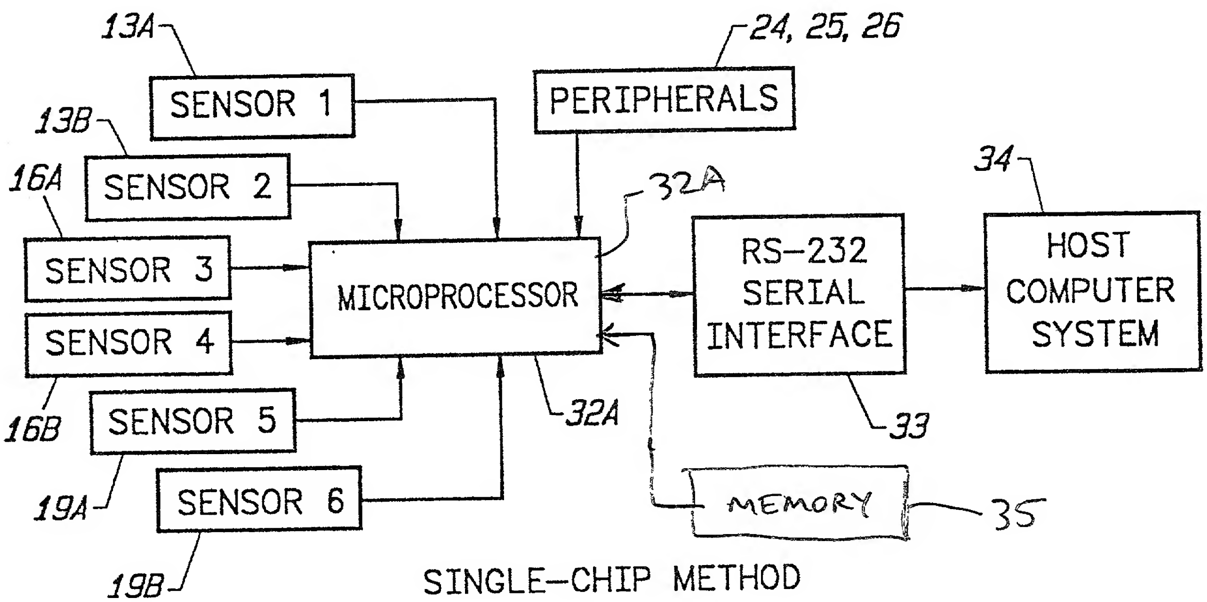
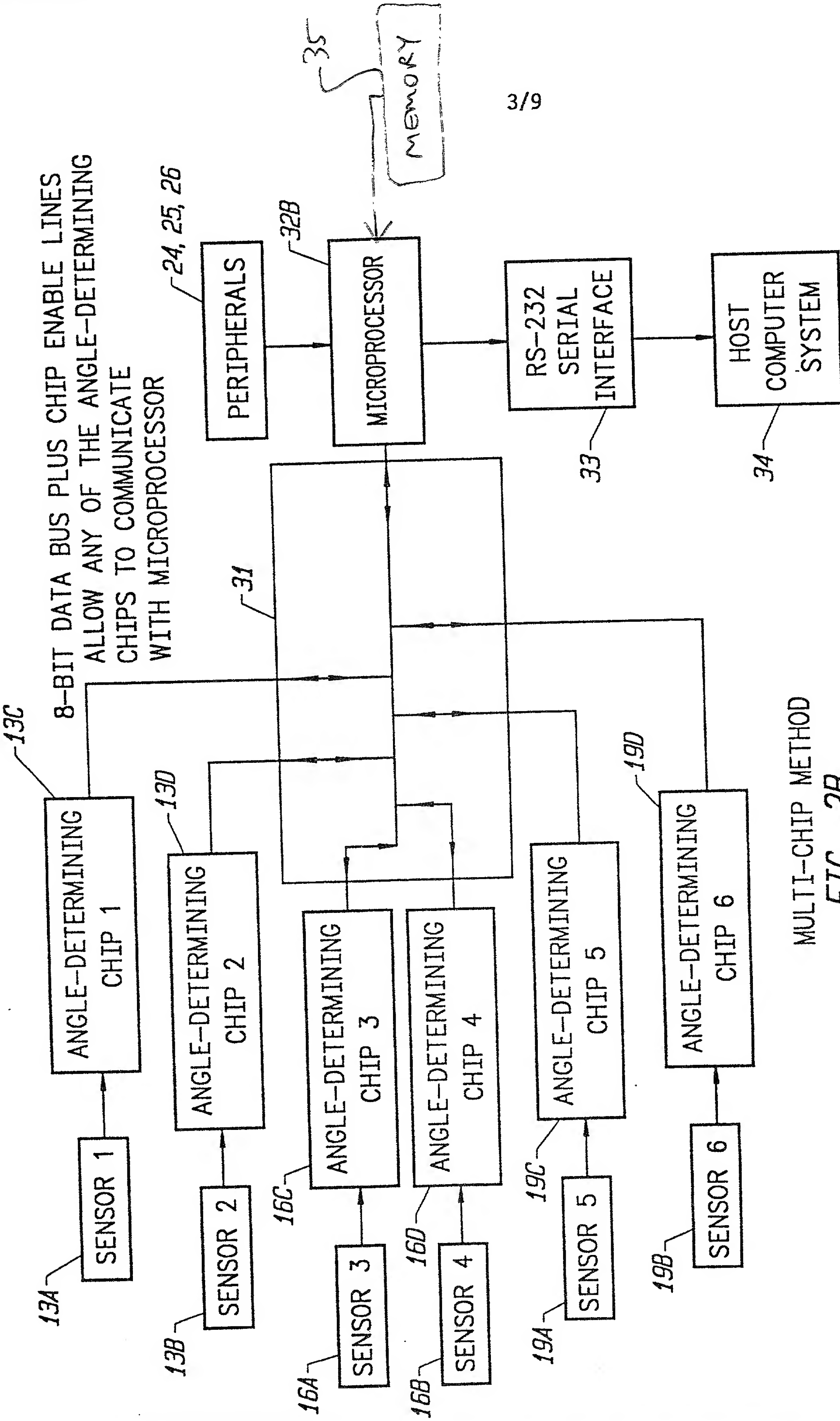

A3
~~AXIS 3~~
A4
~~AXIS 4~~
15
A2
~~AXIS 2~~
17
14
A5
~~AXIS 5~~
19A
16A
16B
27
25'
A1
~~AXIS 1~~
13A
12
13B
19B
18
11
25
24
F
20
11'
AXIS 6
A6
21
26'
23
22
28
32'
26
32A OR 32B
SENSOR AND FORCE SIGNALS
35
MICROPROCESSOR
MEMORY
34''
34'
HOST COMMAND
40
DISPLAY APPARATUS
COMPUTER
34

FIG. 1



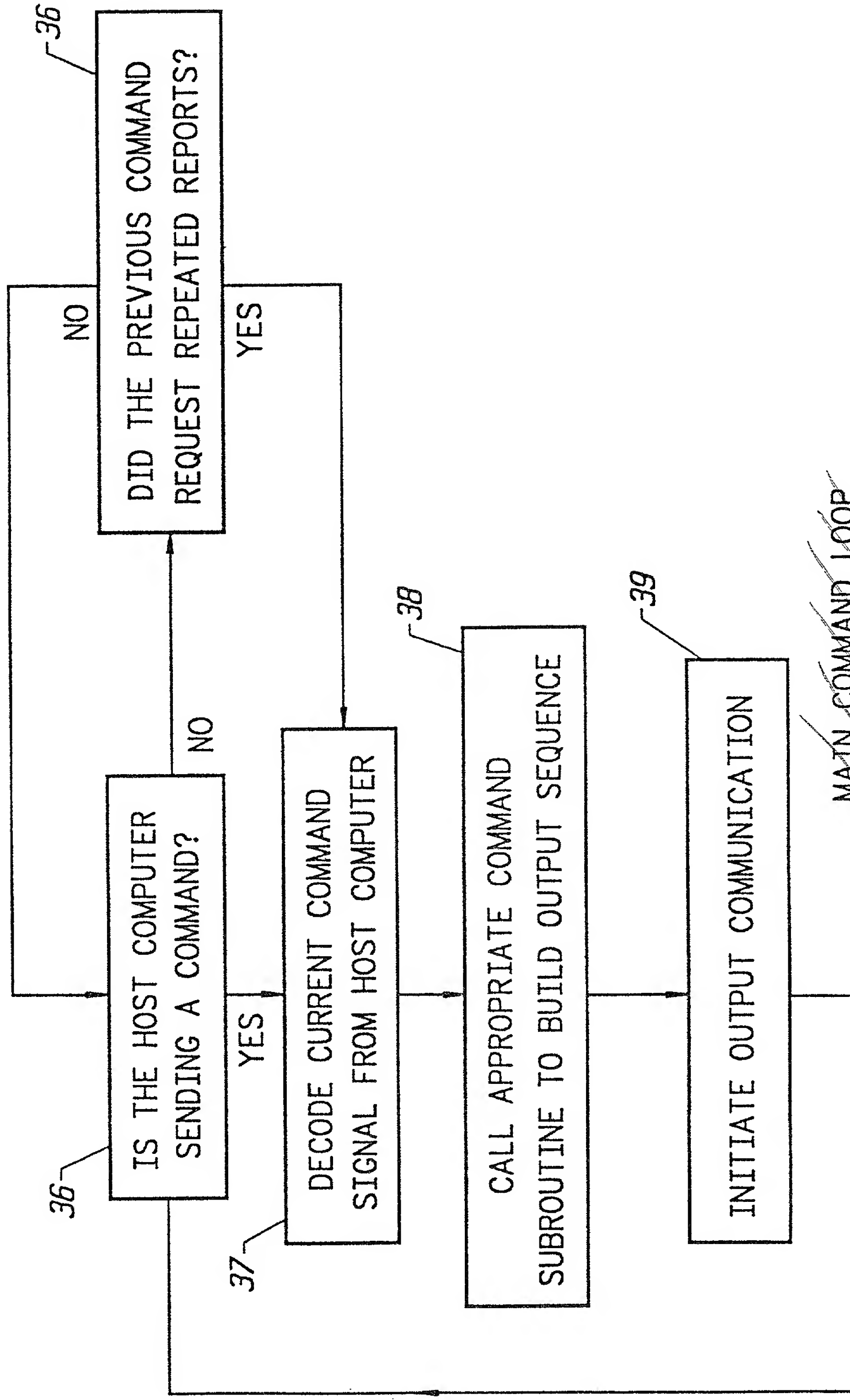
SINGLE-CHIP METHOD

FIG. 2A



MULTI-CHIP METHOD

FIG. 2B



~~MAIN COMMAND LOOP~~

FIG. 3

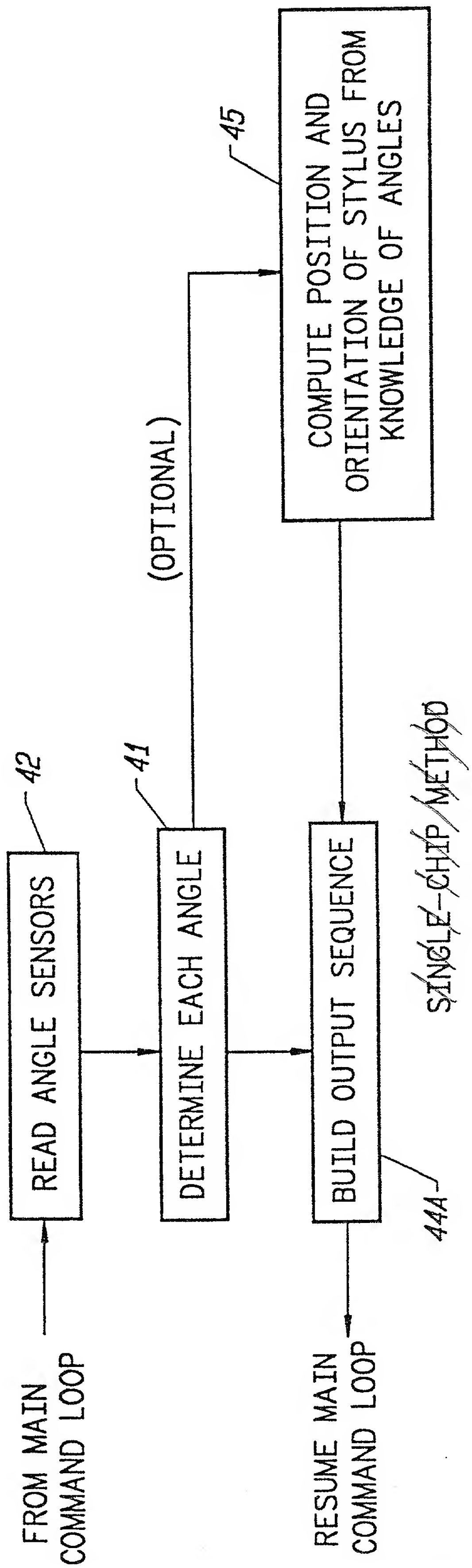

FROM MAIN COMMAND LOOP
READ ANGLE SENSORS
42
DETERMINE EACH ANGLE
41
(OPTIONAL)
COMPUTE POSITION AND ORIENTATION OF STYLUS FROM KNOWLEDGE OF ANGLES
45
BUILD OUTPUT SEQUENCE
44A
RESUME MAIN COMMAND LOOP
SINGLE-CHIP METHOD

FIG. 4B

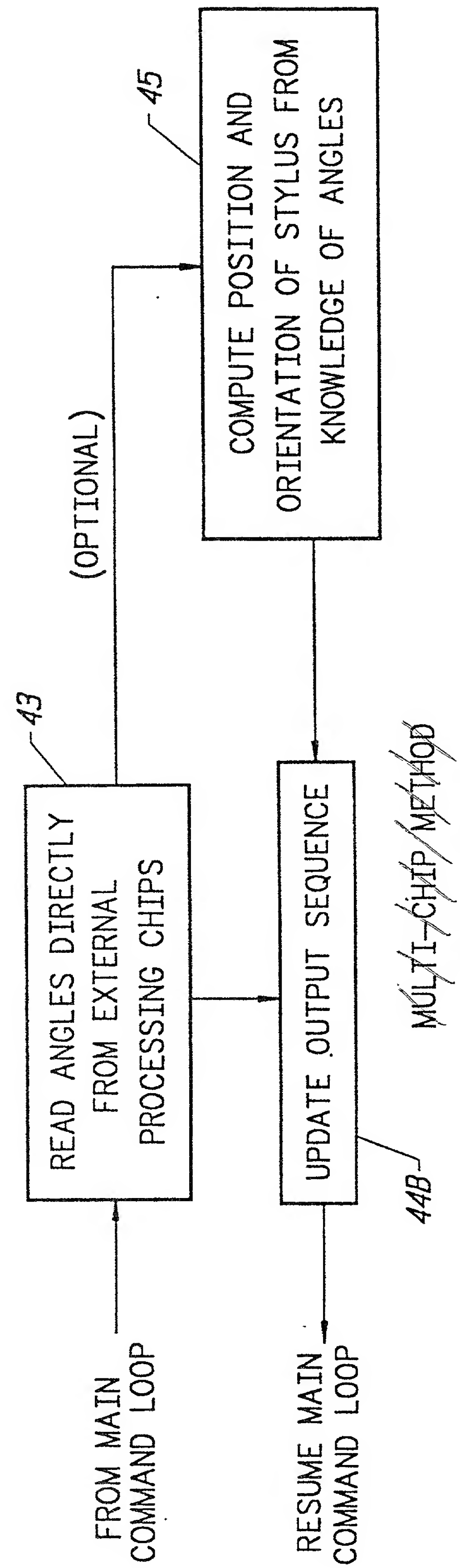
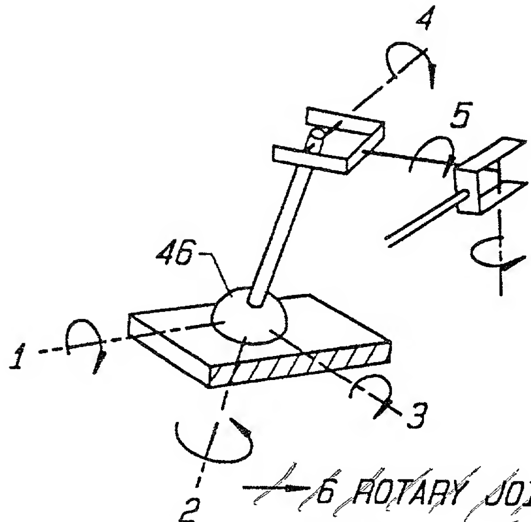
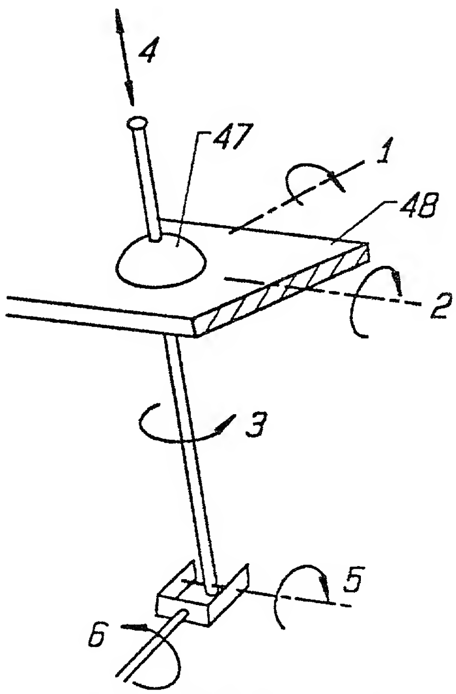

FROM MAIN COMMAND LOOP
READ ANGLES DIRECTLY FROM EXTERNAL PROCESSING CHIPS
43
(OPTIONAL)
COMPUTE POSITION AND ORIENTATION OF STYLUS FROM KNOWLEDGE OF ANGLES
45
UPDATE OUTPUT SEQUENCE
44B
RESUME MAIN COMMAND LOOP
MULTI-CHIP METHOD

FIG. 4A



~~6 ROTARY JOINTS~~

FIG. 5

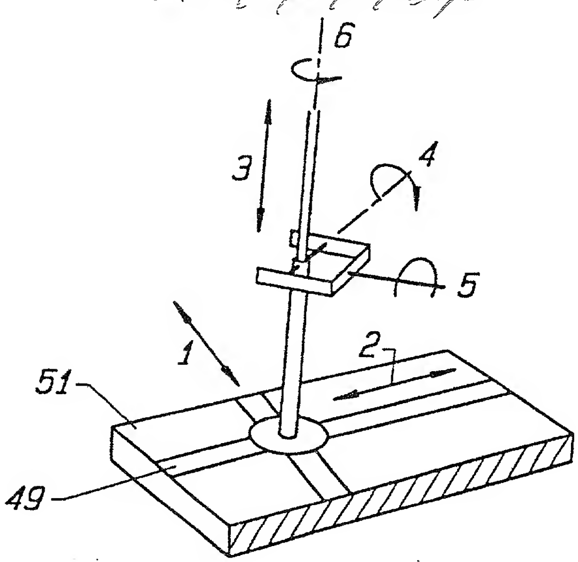


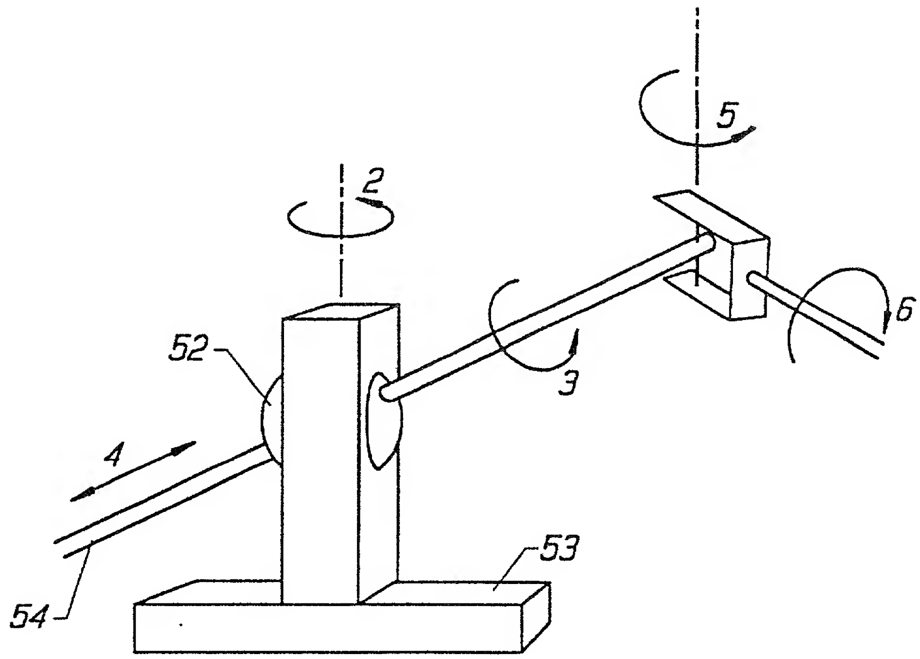
~~5 ROTARY JOINTS~~
~~1 LINEAR JOINT~~

FIG. 6

FIG. 7

~~3 ROTARY JOINTS~~
~~3 LINEAR JOINTS~~





5 ROTARY JOINTS
1 LINEAR JOINT

FIG. 8

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of	Atty Docket No.: IMM007D.US
L. Rosenberg et al.	Examiner: Unassigned
Application No. Unassigned	Art Unit: Unassigned
Filed: 1/8/02	
For: Interface Device for Sensing Position and Orientation and Outputting Force to a User (as amended)	

SEPARATE LETTER TO THE OFFICIAL DRAFTSMAN

Commissioner for Patents
Washington, D.C. 20231

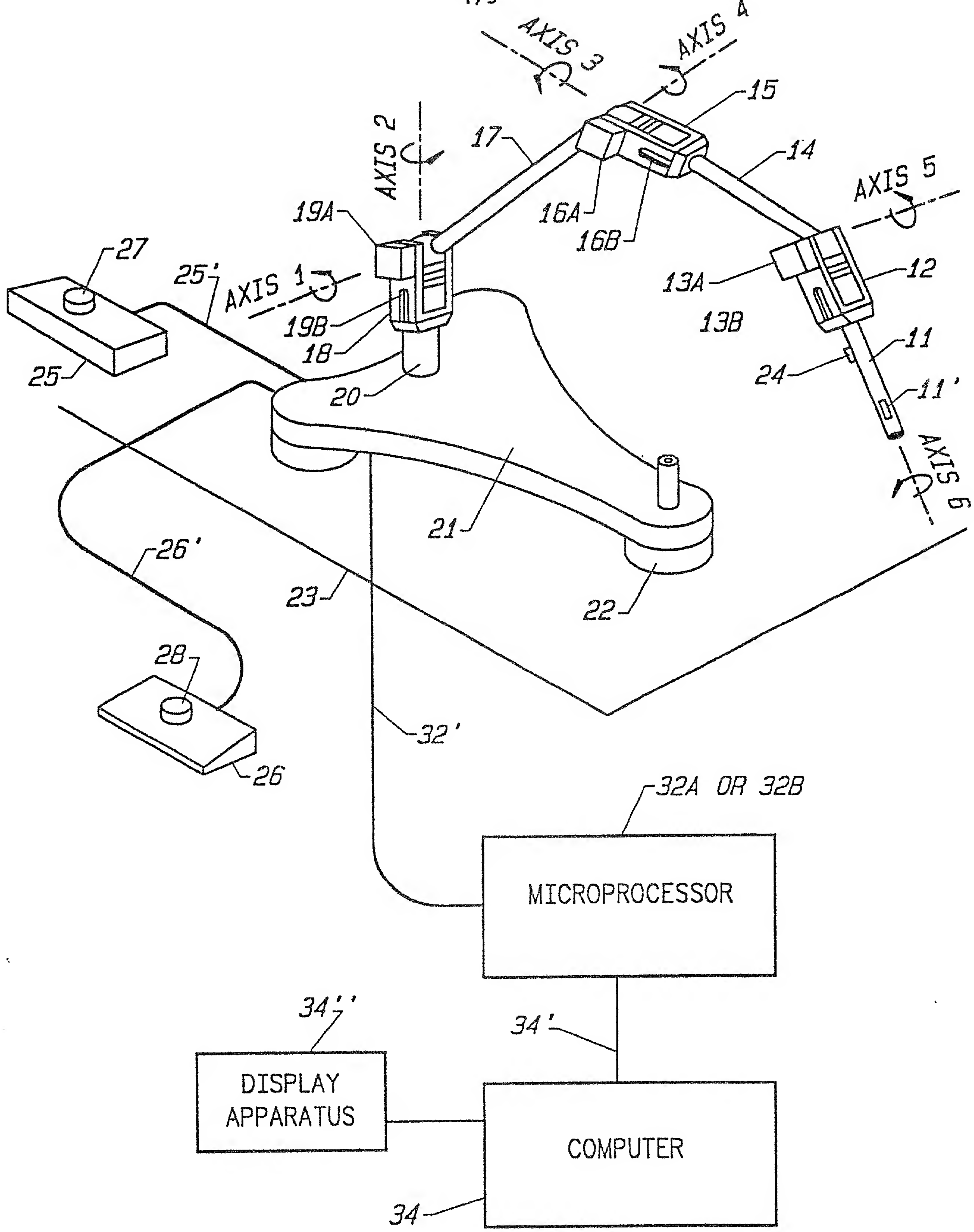
Sir:

Enclosed herewith are nine (9) sheets of formal drawings for the above-referenced case. If the draftsman has any questions concerning these drawings, please contact the undersigned at the number set forth below. If any fees are due in connection with the filing of these drawings, please charge such fees to deposit account 50-1815 (Order No. IMM007D.US).

Respectfully submitted,

James R. Riegel
Reg. No. **36,651**

801 Fox Lane
San Jose, CA 95131
(408) 467-1900


AXIS 3
AXIS 4
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AXIS 2
17
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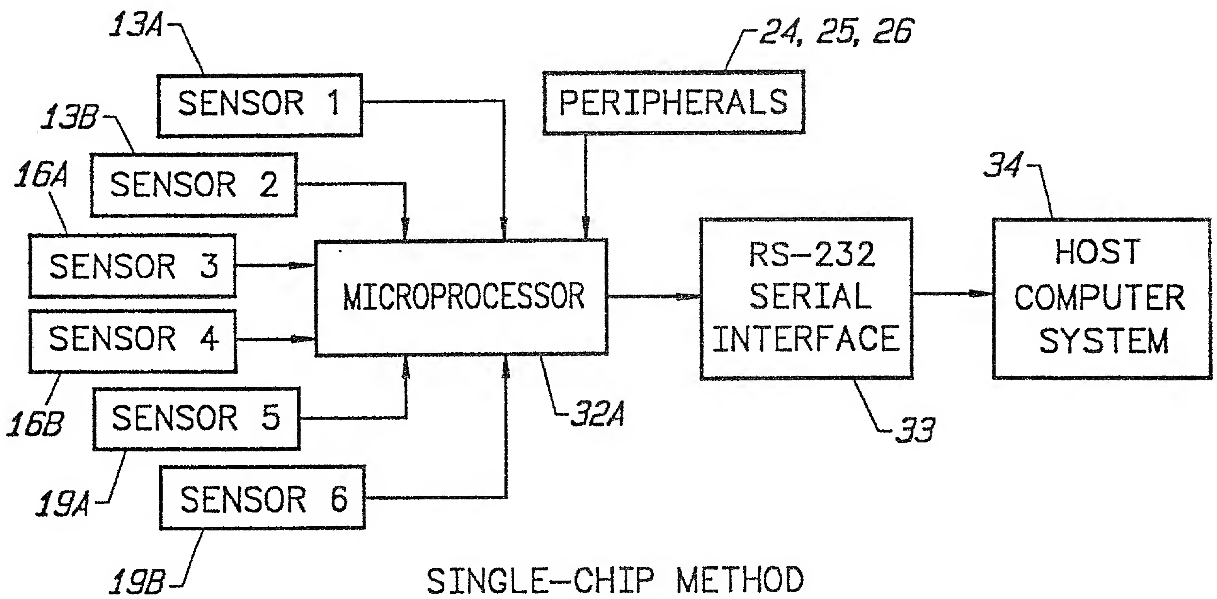
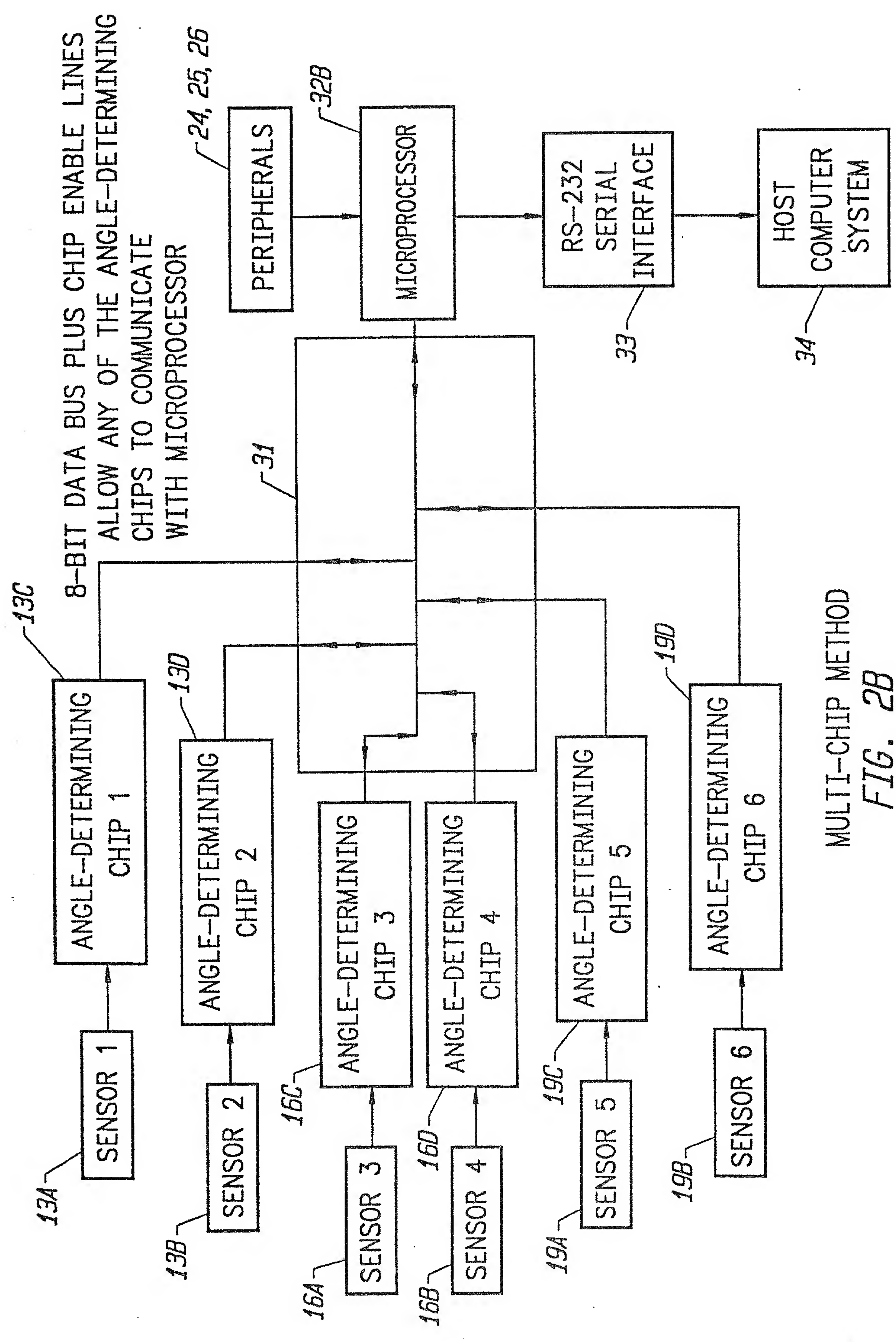
AXIS 5
19A
16A
16B
27
25'
AXIS 1
13A
12
13B
19B
18
11
25
24
20
11'
AXIS 6
21
26'
23
22
28
32'
26
32A OR 32B
MICROPROCESSOR
34''
34'
DISPLAY
APPARATUS
COMPUTER
34

FIG. 1



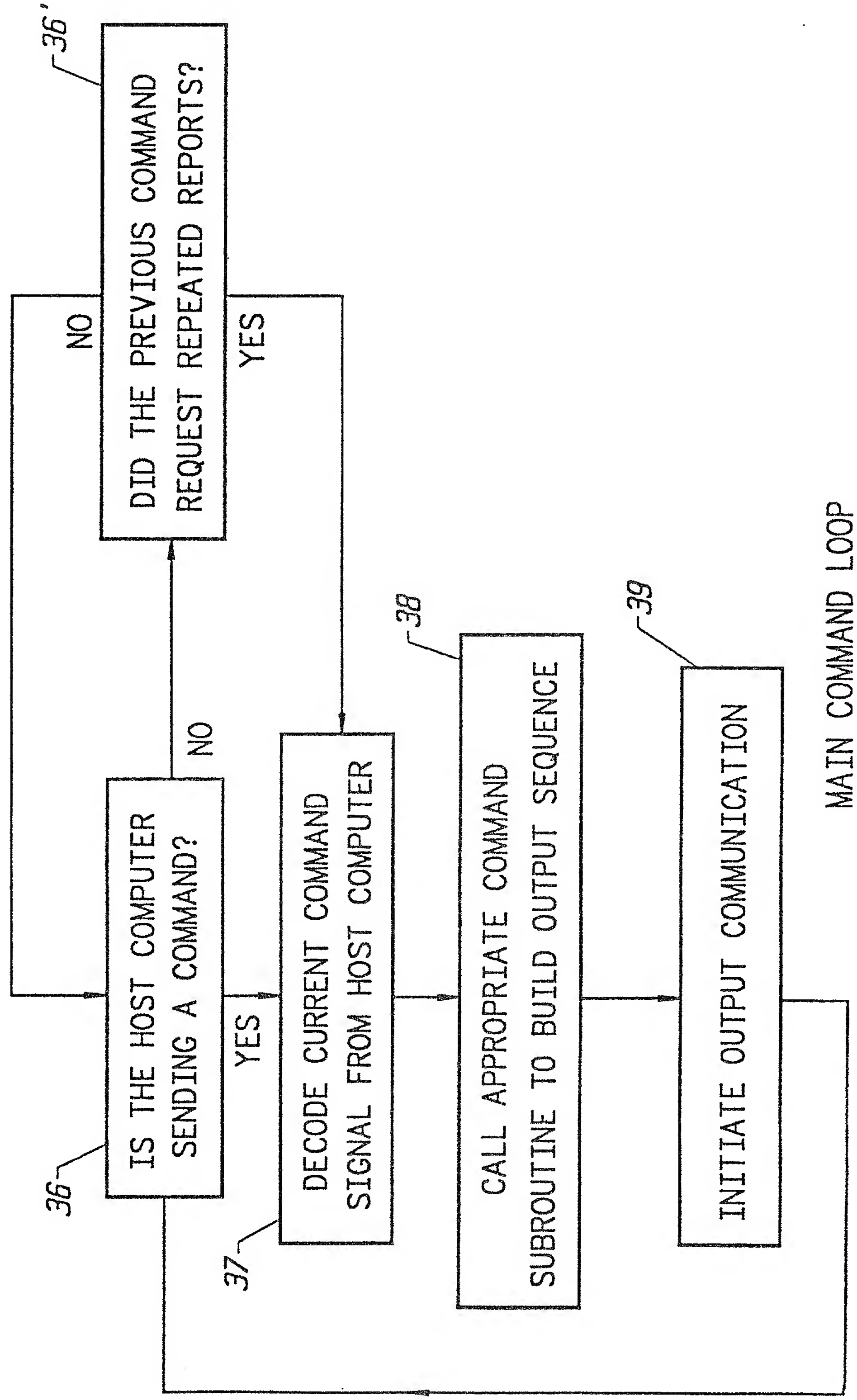
SINGLE-CHIP METHOD

FIG. 2A



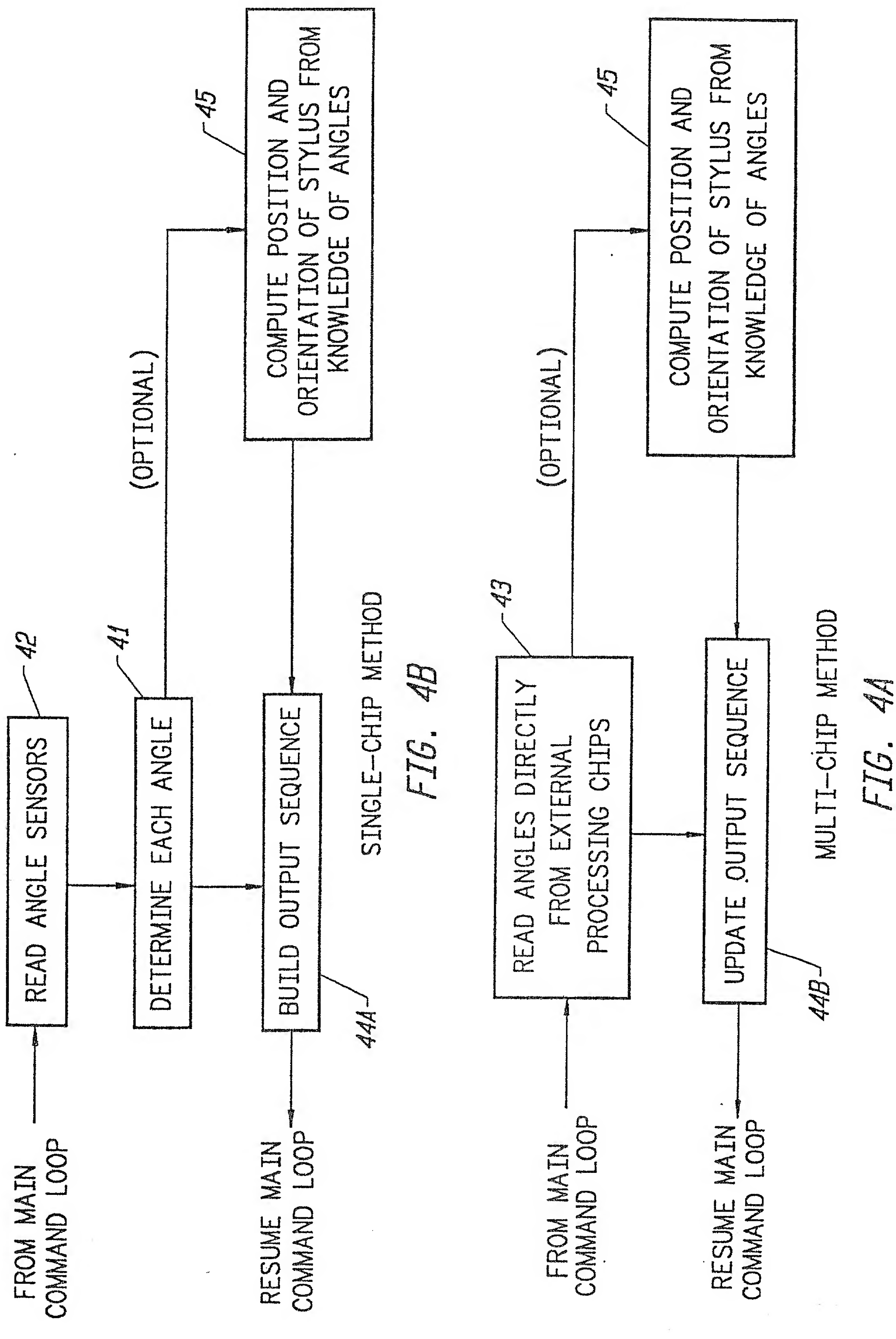
MULTI-CHIP METHOD

FIG. 2B



MAIN COMMAND LOOP

FIG. 3

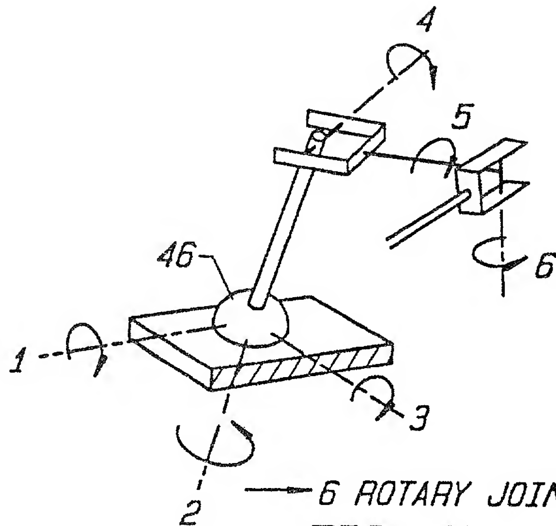


SINGLE-CHIP METHOD

FIG. 4B

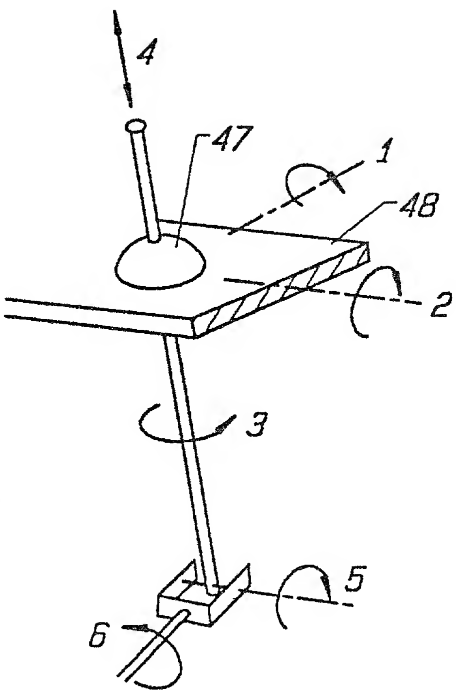
MULTI-CHIP METHOD

FIG. 4A



6 ROTARY JOINTS

FIG. 5



5 ROTARY JOINTS

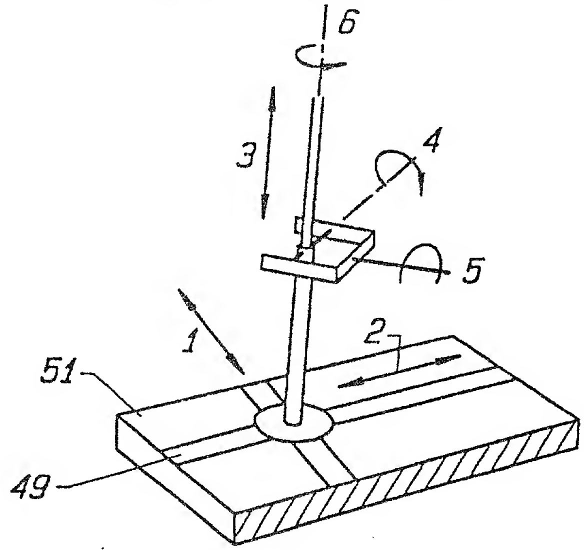
1 LINEAR JOINT

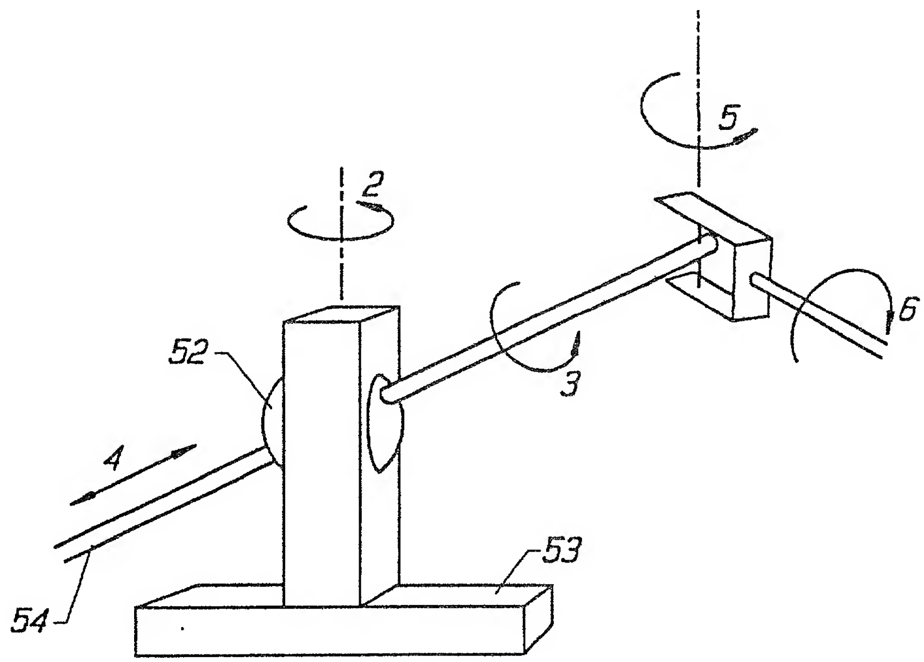
FIG. 6

FIG. 7

3 ROTARY JOINTS

3 LINEAR JOINTS





5 ROTARY JOINTS
1 LINEAR JOINT

FIG. 8

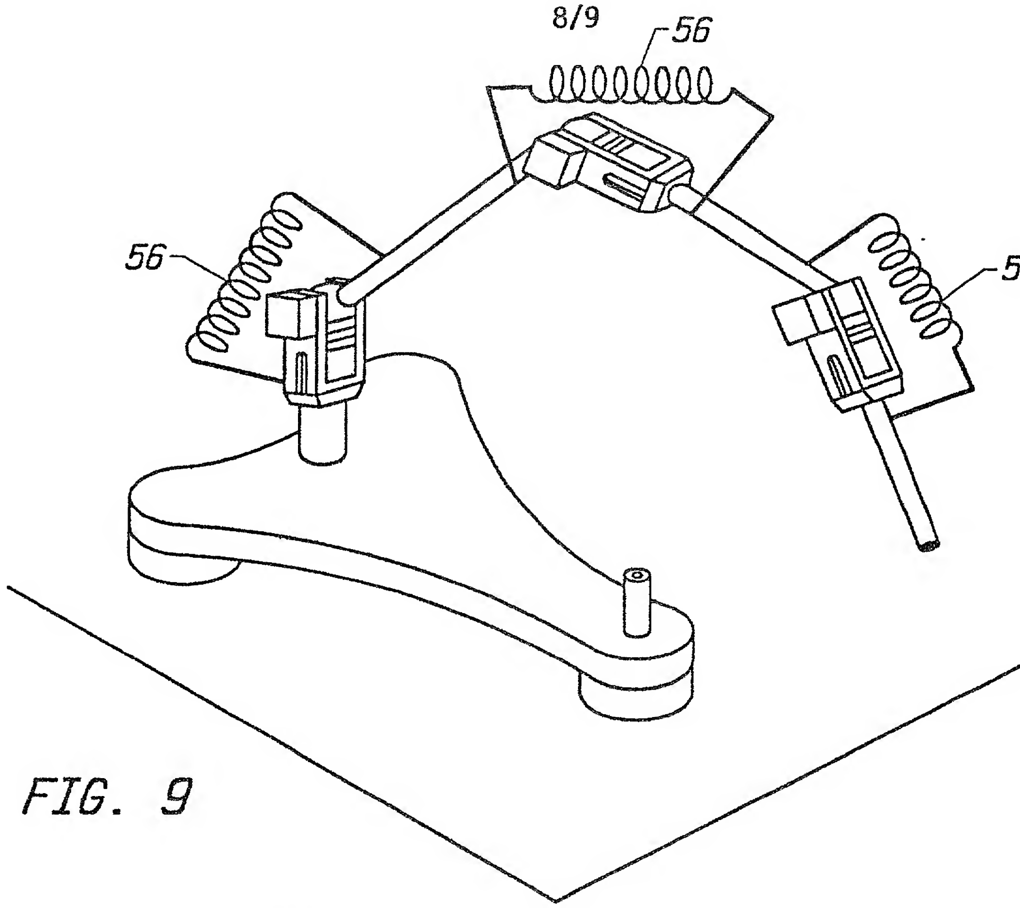


FIG. 9

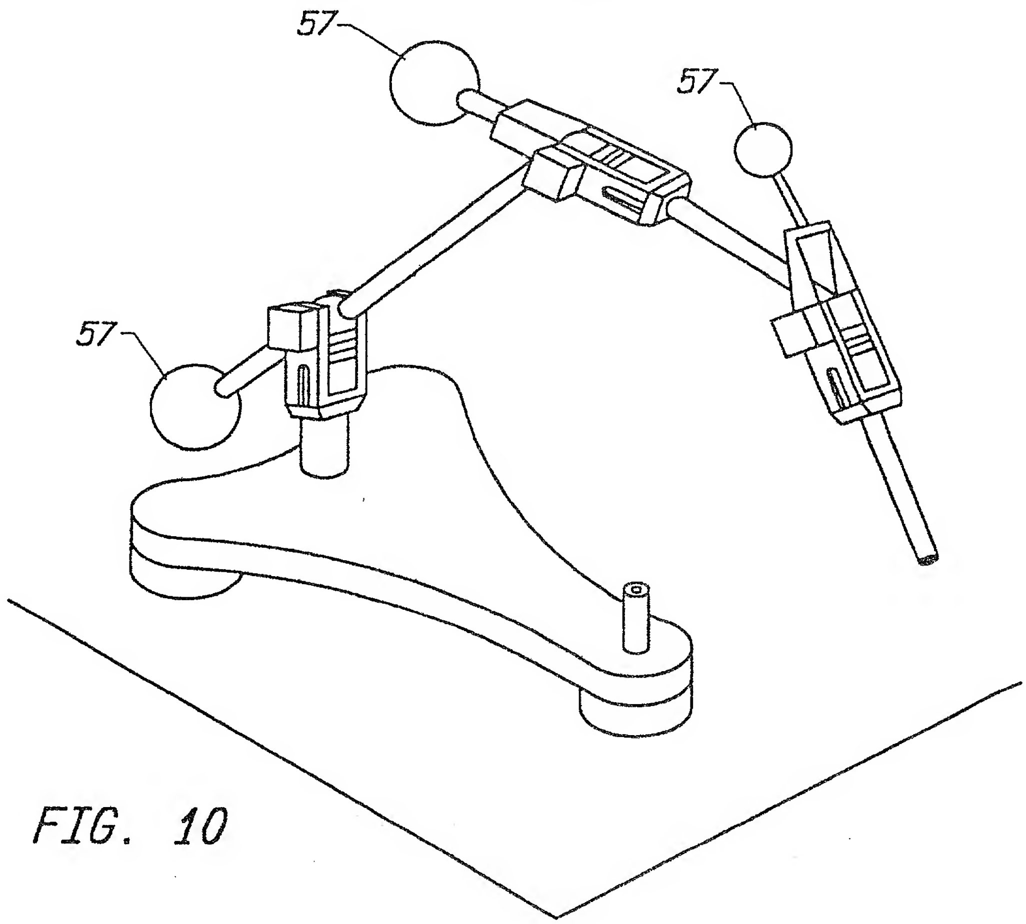


FIG. 10

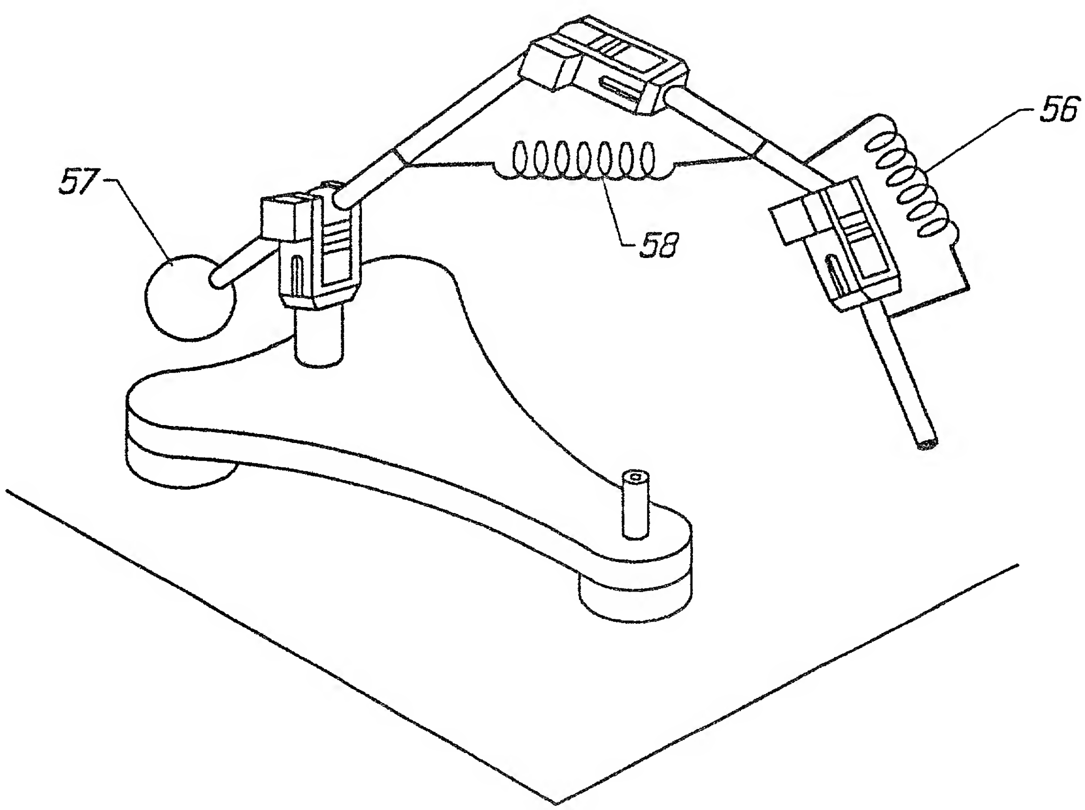


FIG. 11